RESPONSE OF SOYBEAN(*Glycine max* [L.] Merr.) VARIETIES TO SOWING METHODS AND PHOSPHORUS FERTILIZER APPLICATION AT SAMARU, NIGERIA

BY

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(M.Sc. /AGRIC. /7880/2011-2012)

DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
ZARIA, NIGERIA

NOVEMBER, 2015

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN AGRONOMY

DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
ZARIA, NIGERIA

NOVEMBER, 2015

DECLARATION

I declare that this dissertation entitled “Response of Soybean Varieties (*Glycine Max* [L.] Merr.) toSowing Methods and Phosphorus Fertilizer Application at Samaru, Nigeria” was performed by me in the Department of Agronomy under the supervisions Dr. A. A. Muhammad, Prof. M. Mahmud and Dr. Hassan A. Hamidu. The information derived from literature has been duly acknowledged in the text and list of references provided. No part of this work was previously presented for award of another degree, diploma or certificate at any institution.

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(Major Supervisor)

CERTIFICATION

This dissertation titled "**Response of soybean (*Glycine Max* [L.] Merr.) varieties to sowing methods and phosphorus fertilizer at Samaru, Nigeria"** is in conformity with the regulations governing the award of the degree of Masters in Science degree (M.Sc.) in Agronomy of Ahmadu Bello University, and is approved on its contribution to knowledge and for literary presentation.

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DEDICATION

This work is dedicated to the memories of late Professor Ahmed Mustapha Falaki, whose life was dedicated to service in the field of research towards the enhancement of humanity. May his gentle soul rest in peace, May Allah SWT forgive him and grant him Jannatul Firdausi as his eternal abode, Amin.

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30th November, 2015

ABSTRACT

Response of soybean*(Glycine max* [L] Merr.) varieties to sowing methods and phosphorus fertilizer application in Northern Guinea Savannah was investigated under field and pot conditions at the Institute for Agricultural Research (IAR) farm and the Department of Agronomy orchardrespectively, in Ahmadu Bello University, Samaru. The treatments consisted of two soybean varieties;TGx1835-10E and TGx1951-3F,two sowing methods (drilling and dibbling) and four P fertilizer rates of (0, 11, 22 and 33kg P ha^{-1}) factorially combined and laid out in Randomized Complete Block Design(RCBD) and replicated three times the crops recorded faster growth and higher yield in the field compared to the pot trial. Result revealed that soybean variety TGx1951-3Frecorded taller plants with higher dry matter production but took longer days to attain 50% flowering than TGx1835-10E. It also out performed TGx1835-10E in pod weight and grain yield.Dibbling recorded higher soybean stands, numbers of leaves and branches per plant and total dry matter production than drilling in both trials. It however, recorded lower RGR and took shorter days to attain 50% flowering than drilling in terms of yield and its attributes. A positive linear response on both soybean varieties was recorded with increasing P fertilizer application up to 33kg P ha^{-1} in both trials. Positive and highly significant correlation coefficients (>0.05) were obtained between grain yield and plant height, number of leaves, number of branches, canopy spread (12WAS),number of pods per plant andpods weight per plant.Similarly number of pods per plant andpods weight of per plantrecorded a positive and highly significant correlationwith grain yield, plant height, number of leaves, number of branches and canopy spreadin the field trial. In the pot trial a highly significant and positive correlation between grains yield and plant height, canopy spread and harvest index was recorded. Grain yield and number of branches, plant height and number of branches per plant, days to 50% flowering and pods weight per plant showed a positive and significant correlation.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 ORIGIN AND DISTRIBUTION OF SOYBEAN

Soybean plant (*Glycine max* L.Merr.)is a member of the Leguminosae family. Soybean is also known as Chinese or Manchurian beans. It is an ancient food crop believed to have originated from China where it has been grown for over 5,000 years (Hymowitz, 1970). Chinese writings on soybean dated back to 2,800 B.C where it was named as one of five sacred crops. According to the ancient Chinese myth, in 2853 BC, the legendary Emperor Shennong of China proclaimed that five plants were sacred: soybeans, rice, wheat, barley, and millet(Hymowitz and Kaizuma, 1979).Cultivation of soybeans was long confined chiefly to China, but gradually spread to other countries. The oldest preserved soybeans were found in archaeological sites in Korea dated to about 1000 BC. It is uncertain if they were wild or cultivated strains (Crawford *et al.*, 2003).The distribution of soybean spread gradually from Northern China to East and South Asian countries of Manchuria, Korea and Japan between 2,000 BC and the third century A.D (Hymowitz and Kaizuma, 1979). Soybean cultivation largely remained confined in this region until 1875 when Haberlandit's work resulted in the production of seeds from 19 Chinese and Japanese varieties at Vienna which resulted in its subsequent distribution to other parts of Europe (Caldwell*et al.*,1973).Samuel Bowen, a sailor who had visited China, introduced soybeans to America in 1765(Brachfeld and Choate, 2007). Soybean first arrive Africa in Egypt in 1857, to small farm land holders in East Africa in 1908 through the trade links with Asians and East African nations (Bichi, 1982).

Soybeans was reported to been introduced into Nigeria in about 1908. It was mainly restricted to that part of Nigeria now referred to as Benue State and the Zonkwa – Abuja ecological zones (Ogundipe*et al.*,1989). The cultivation of soybean is increasing in the savannas of Nigeria for several reasons. It is becoming a major food and cash crop and is widely used in the food and feed industry (Brader 1998; Sanginga *et al*., 2002). It contributes to improving soil fertility and reducing Striga infestation on farmers' fields (Sanginga *et al.,* 2002; Franke *et al*., 2004). Farmers have adopted new varieties developed at IITA (Okogun *et al.,* 2004) that store well and, unlike cowpea, do not need expensive pesticides. They also nodulate freely with native rhizobia strains and take care of a large proportion of their nitrogen (N) fertilizer requirement through biological N fixation once the plants are established (Okogun *et al.,* 2004) without depleting soil N reserves (Singh et al. 2003). Some of the soils in the savannas of northeast Nigeria with organic carbon below 0.5% can hardly supply the quantities of N required for reasonable crop yields (Carsky and Iwuafor 1995). Although the development and introduction of several varieties of soybean have resulted in a tremendous increase in production in the Nigerian savannas, sustainable production is constrained by prevailing soil low P levels (Ogoke *et al.,* 2003). Pal et al. (1989) observed that the grain yield of soybean responded to P fertilizer in 10 of 11 trials in northern Nigeria. The process of biological N_2 fixation by nodules of legumes requires large amounts of P, and its availability is a primary constraint to N_2 fixation and therefore to the N economy of many tropical ecosystems (Danso, 1992). Deficiencies of soil nutrients, especially P, may restrict the development of a population of free-living rhizobia in the rhizosphere, limit the growth of the host plant, restrict nodulation itself, and cause an

impaired nodule function (Danso, 1992). Low levels of soil available N and P and large crop responses to application of N and P fertilizer are common for both cereals and legumes in the moist savanna of west Africa (Batiano *et al.,* 1986). Apart from increases in yield, the application of P to soybean enhances the amount of N derived from the atmosphere by the soybean-rhizobium symbiotic system (Sanginga *et al.*, 1996) resulting in an increase in the N content of the roots, haulms, and leaves. These residues, when left on the soil, will mineralize and add to the soil part of the N derived from the atmosphere. Soil P levels are very low in the Sudan and Guinea savannas of northeast Nigeria. Kwari (2005) found P levels ranged from 0.3 – 10.4 mg kg^{-1} in the southern Guinea savanna (SGS), from 1.4 – 9.5 mg kg^{-1}in the northern Guinea savanna (NGS) and from 0.3 – 7 mg kg^{-1}in the Sudan savanna (SS). He further reported that P levels were lower (below the critical values for the Nigerian savanna; 5 7 mg kg-1) in 78% of fields surveyed in the SGS, in 92% in the NGS, and in 93% in the SS. He attributed this low P status to the suboptimal amounts of P applied by farmers and/or P-sorption particularly in the SGS and NGS where the soils are derived from basalt. Such soils are rich in Fe and Al oxides and generally exhibit high P sorption (Singer, 1987). Kwari (2005) concluded that the poor soil-P status would have implications for the production of legumes, such as cowpea and soybean, which would require P for their root development and N fixation. Their effectiveness in soil improvement can be hindered by P deficiency (Giller and Cadisch, 1995).

Nigeria has a land area of about 570,000 hectares devoted to soybean production amounting to about 580,000 metric tons (FAO, 2012) with Benue, Kwara, Kaduna, Plateau States and the Federal Capital Territory being the leading producers (Anon. 1994 and 1995).Soybean global Production last year (USDA, 2014) was 318.68

million tons. This year's 321.02 estimated million tons could represent an increase of 2.34 million tons or a 0.73% in soybean production around the globe.Soybean production in some Countries (Values in Metric Tons):-Brazil:88,000,000, United States:85,700,000, Argentina:53,500,000, China:12,100,000. The US used to produce the most soybean, but large amounts of fertile land, water resources and low labour costs have fuelled explosive growth in South America, particularly in Brazil which has taken over the lead (USDA, 2014).

1.2 Ecological Requirements

Soybean grows well in warm and moist climate, it grows well in soil of pH 6.0 or higher, but can also tolerate a pH of 4.3–4.8. Available phosphorus (P) levels critical for soybean production range from 10 – 15 mg kg^{-1} soil (Aune and Lal 1997). Soybean grows from sea level, up to 2 000m; from equator to latitudes 55 ^{o} N and 55 ^{o}S. It grows under a wide range of temperature, the minimum temperature for performance of growth is about 10°C and lower temperature tends to delay the flowering. Day length is the key factor in most of the soybean varieties as they are short day plant and are sensitive to photo-periods. Soil temperatures of 15.5°C or above favor rapid germination and vigorous seedling growth, most of the varieties will flower and mature quickly if grown under conditions where the day length is less than 14 hours provided that temperatures are also favorable.The optimum temperature for growth and development is 30^{o}C whilst for proper emergence of seedling, a seedbed temperature of 25–33^{o}C is optimal.The crop requires 500–850 mm water during the growing season.The high moisture requirement is critical at the time of germination, flowering and pod forming stages. However, dry weather is necessary for ripening(Krishna and Sachdev, 2014).

1.3 Economic Importance

Soybean (*Glycine max* L.) is the world's most important food legume of greatnutritional value**.** Soybean is one of the most important sources of oil and protein and is commonly used in both human and animal diets (Ariyo, 1995). The crop has the highest protein content (40%) of all food crops and is equivalent to proteins of animal products. It's second only to groundnut in terms of oil content (20%) among food legumes. (Fouilleux*et al*., 1996; Kyei-Boahen*et al*., 2002a). Soybean is increasingly becoming important as a source of oil for biodiesel production,this trend is likely to continue, at an even faster rate, considering the volatility in crude oil prices and/ or the environmental concerns related to the use of crude oil (Krawczy, 1996).

Soybean oil is used in the production of edibles such as margarine, salad cream, butter, lard, cooking oil etc. The dried beans can be processed into coffee substitute, vegetable milk, cheese and yoghurt. The earliest known use of soybean in the Nigerian diet was in the form of dawa-dawa, a fermented soup condiment traditionally made from the locust beans. Presently most of the dawa-dawa produced in Nigeria use soybean as its raw material (Ogundipe*et al.*, 1989).

Soybean is also used in the production of local delicacies like 'Kamu', 'Akara' or 'Kosai', 'Awara' and wide range of soups. It has been found to be an important alternative to baby milk products used during weaning. The fodder is used as an animal feed. Soybean is used as a forage crop and feed for animals in form of silage. It is valued for improvement of soil fertility improvement by providing biologically fixed nitrogen, increasing soil organic matter, providing protection against soil

erosion as a cover crop and it is used in crop rotation (Jummai, 2002).Presently 208,556 hectare of land is under soybean cultivation producing 197,333 tons of soybean seeds at an average of 315 kg/ha (FAO, 2010).

1.4 Justification of the study

Nigeria's optimum production potentials of soybeanis yet to be realized despite its lead in Africa with 946 kg/ha, (IITA, 2011). Nigeria's domestic production of soybeans is continuing to trend upwards, but still does not meet the growing demand. Despite this steady increase, domestic output continues to lag behind rising demand. Increased production is constrained by low yield levels resulting from biotic and abiotic stresses like disease, low nutrient and moisture deficit. Plant efficiency for nutrient uptake and utilization may improve yield potential in situations of soil nutrient stress, reducing plant demands for a given level of crop yield. The application of P improved biomass production, nodulation and P uptake and decreased root to shoot ratio, root length and surface area and P utilization efficiency (Burriro *et al*., 2002).

Until recently soybean production in Nigeria has been low.Following the development and introduction of improved varieties, many food recipes using soybean were found to be highly acceptable to Nigerians, including their incorporation into traditional local dishes (Osho and Dashiell, 1998). Substantial efforts were made to promote soybean utilization technologies among rural and urban households.The fertility of savanna soil is generally low especially with respect to P (Sanchez, 1976) but crops respond well to fertilization because of its favorable base-exchange properties(Mokwunye, 1979). The demand for a reasonably correct

evaluation of the performance, beneficial or otherwise of P in soybean is rapidly increasing, thus emphasizing the need for intensive investigation on the response of P fertilization in relation to soybean productivity in this zone.Since P is very immobile in the soil, plant attributes that lead to enhanced P acquisition efficiency are related to the extent to which roots are able to intercept more soil available P or to mobilize P from poorly soluble sources. These attributes include root architecture, root morphology, mycorrhizal associations, high affinity transporters, and rhizosphere alteration (Lambers *et al.*, 2006).

The complex relationship between yield and sowing method has been a subject of considerable arguments; some researchers are of the opinion that drilling waste seeds, while dibbling conserves seed. In the last two decades, the IITA has developed new varieties capable of nodulating in association with local rhizobia, in addition to possessing other good agronomic traits. The institute has also developed and released rust resistant soybeans varieties (IITA, 2011). The limitations curtailing soybean production in Nigeria apart from the dearth of awareness are numerous. The availability of new varieties with improved lodging resistance and herbicides with greater selectivity may lead to an accelerated acceptance of narrow row soybean production systems to capitalize on the increased yield potential in the northern growing regions (Costa, *et al.*,1980).Factors such as difficulty associated with cooking soybean and flatulence, lack of recognition of the potential of the crop (Bichi, 1982), poor seed viability, poor relative pricing offered by defunct marketing board and poor agronomic characteristics of the available cultivars have all curtailed the attainment of our full production potentials (EmechebeandYuwa, 1983). However, at present, there is increased awareness on the crop. The introduction of on-

farm trials in Nationally Coordinated Research Programmes from 1984 has resulted in adoption of soybean as a commercial crop. Thus soybean has spread to areas previously considered unsuitable for its production.

Furthermore, as new varieties of soybean are continuously being developed to meet food demand and biodiesel production, it is important to evaluate these new varieties, in terms of the best yielding cultivars and appropriate fertilizer rates (Ogola*et al.*, 2006).Several factors are believed to have contributed to the reduction of soybean yields in farmers' field among which are poor weed management strategies, insufficient rainfall particularly at grain filling stage, non use of improved varieties that are less susceptible to diseases and shattering, sowing at sub-optimal population and lack of or insufficient fertilizer application among others (Shebayan and Lagoke, 1986).

The objectives of this study were to:-

(i) Evaluate the effect of different rates of phosphorus fertilizer on soybean growth and yield.

(ii) Assess the performance of soybean to different sowing method.

(iii) Compare the response and productivity of two new soybean varieties.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Varietal Variation of Soybean

A wide range of genetic variability has been observed in soybean germplasm (Verma and Thomas, 1991). Which provides a vast potential for exporting various useful economic traits. These accessions vary in days to flowering (22 – 78 days), days to maturity (68 – 140 days), the number of leaflets (3 - 4), plant height (8.7 – 122.0cm), number of seeds per pod (1.3 – 3.9), yield per plant (0.1 – 3.0g) and oil content (13.0 – 24.7%). Variability in qualitative characters may be found in flower color (purple or white), pubescence color (tawny or grey), pubescence type (apprised, semi-apprised, erect or curly), pubescence density (normal, dense, sparse, semi-sparse or glabrous), leaf shape (normal, narrow, broad or small), leaf color (light green, green or dark green), pod color (light brown, brown or light black), seed coat colour (yellow, yellowish green, olive green, chocolate, light brown, brown, black, light grey or black shedding to buff), reaction to bacterial pustules, soybeans mosaic and pod blight (free, moderate or susceptible), pod shattering (free, moderate or susceptible), pod shattering (free, moderate or susceptible) and growth habit (determinate, semi-determinate or indeterminate) (Verma and Thomas, 1991). Pod shattering is a serious problem in tropical climates, where day temperatures can be very high at the time of maturity. Yield losses due to pod shattering range from negligible to as high as 90% depending upon the time of harvesting, environmental conditions and genetic endowment of the variety (Verman, 1992).

Soybeans has a short life and the problem of poor stand establishment is pronounced, especially under tropical conditions where seed deterioration is accelerated by high temperatures and humidity, (Kueneman, 1982).Egli et al., (1973), posited that the determinate cultivars had higher growth rate attaining 84% of its maximum height at the onset of flowering than the indeterminate which attained only 68% of the maximum growth at that stage, but the indeterminate produced only 84% of its shoot dry weight at flowering as opposed to 92% in the case of the determinate cultivars. The principal factors influencing canopy and net photosynthesis are genotype (cultivars), height and leaf area index.

2.2 Effectsof Phosphorus on Growth and Yield of Soybean Varieties

A more comprehensive understanding of the mechanisms of phosphorus (P) efficiency is agronomically significant to advance in the design of crop management schemes that increase P efficiency and reduce the need of fertilizers. Phosphorus efficiency is defined as the ability of a plant to acquire P from the soil and/or to utilize it in the production of biomass or the harvestable organ. Because most parameters related to P efficiency vary according to the growth conditions and isolation of the individual effect of P efficiency is not straightforward; plants must be grown in uniform experimental conditions to obtain a fair comparison of their nutrient acquisition and utilization (Fernandez*et al.,* 2009).

Application of P is reported to affect most of the growth and yield parameters of soybean. Leaf area index and plant height were generally increased with application of P, thus indicating the essentiality of P as a nutrient requirement for soybean (Chiezey*et al.,* 1992; Chiezey*et al.,* 1993).Scientists are on the agreement that

soybean responds to P readily, but the optimum level has remained the bond of contention. Afolabi and Osiname (1980) recommended 12kg/ha P for the forest zone, while Cheizey etal., (1991) recommended 26kg/ha P for the Northern Guinea Savannah zone of Nigeria. Application of P affected most of the growth and yield parameters. LAI and plant height were generally increased with application of P. These growth parameters have been shown to increase with P application, indicating the essentiality of P as a nutrient requirement for soybean (Chiezey*et al*., 1992; Chiezey*et al*., 1993). The application of P stimulated leaf expansion; hence more light interception for photosynthetic activity and high assimilate accumulation. Number of days to 50% flowering remained unchanged with P application contrary to the earlier reports by Chiezey*et al*., (1992) where P application increased the vegetative phase, while nodulation increased with P application.The application of P ensured larger nodules which increased symbiotic activity culminating in more N fixation in the plant, particularly grain yield and total dry matter (Pal *et al.*, 1983; Chiezey*et al.*, 1992).

Continuous application of P fertilizers to soybean may lead to a build-upof available P in the soil, which reduces the subsequent rate of P application. Several studies have been conducted to evaluate the response of soybean and other crops to residual P in the soil (Bolland and Barrow, 1991). Studies elsewhere show that low soil P availability and poor utilization efficiency of the added P is a major constraint limiting the productivity of soybean (IITA, 2011). However, the use of P fertilizer is limited by its high cost, while organic inputs do not provide sufficient P for optimum crop growth due to their low P concentration (Aulakh*et al.*,2003).

2.3 Effects of Sowing Method on Growth and Yieldof Soybean Varieties

Sowing pattern is the distribution and arrangement of plants stands on the ground, which determines the shape of the area available to individual plants (Abaver, 1984). Sowing method can be said to be the determinat of plant population. Chandel et al., (1987) reported that pods per plant, seed per pod, 1000-seed weight, plant height, number of nodes and protein content in general decreased with increase in population. Shroyer and Whigham (1981) in U.S.A reported increased plant height, number of nodes and lodging with increasing row spacing. However, Kanock et al., (1982), working also on population in Thailand found that among the yield components only the number of pods per plant was reduced when density was increased.

Rows are spaced from 21 to 38 (cm) apart depending on the fertility of the soil and the variety grown. Rows are more widely spaced on soils of lower fertility and for the larger, later-maturing varieties. If soybeans are grown for hay, green manure, or soiling purposes, they are usually planted in rows that are very close together or in what is commonly referred to as a solid stand (Deaker, *et al*., 2004).Increasing plant populations decreased the number of branches per plant and increased lodging, seed weight, and Leaf Area Index. While the LAI increased as plant population increased in both the narrow and wide rows, no correlation existed with grain yield. Increasing the plant population in each row-spacing increased the height of the lower pod by a range of 40 to 50%.

2.4 Interaction of Phosphorus and SowingMethods on Growth and Yield of Soybean Varieties

Differences exist among plant species or even among genotypes in the strategies employed for enhanced P acquisition under limiting conditions. Root characteristics, capability for mycorrhizal fungi infection, and rhizosphere modification through exudates are considered important traits for this process. Genotypic differences have been reported in the growth of promiscuous cowpea (Sanginga *et al.*, 2000) and soybean (Abdelqadir, 1998) under low-P conditions. Krasilnikoff et al., (2003) found large differences in the ability of cowpea genotypes to utilize soil P from strongly bound P pools. These pools may include sparingly soluble P associated with aluminum (Al), iron (Fe), and calcium (Ca). The ability of soybean genotypes grown in the same environment as cowpea to utilize these forms of P has not been assessed.

Fertilization at 20, 40 and 60 kg P ha^{-1} had 16.67, 42.50 and 51.20% yield advantage over unfertilized treatment. When the crop was grown without soil inoculation, 20 kg P ha^{-1} was enough for the soybean to accumulate higher shootdry matter and number of pods per plant. However, for seed and soil inoculations, 40kg P ha^{-1} was identified as optimum (Bekere and Hailemariam, 2012). A significant interaction effect between P and variety on plant height, number of branches, canopy spread, TDM and CGR was recorded. Ndako (1996) reported similar findings.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Site Description

Field experiment was carried out during the rainy seasons of 2012 at the Research farm of the Institute for Agricultural Research (11^{o} 11^{i} N and Longitude 07^{o} 38^{i} E, 686m above sea level) and a pot experiment was conducted at the orchard farm of the Department of Agronomy, Ahmadu Bello University, Samaru, Zaria.

3.2 Weather Data

Information on temperature, rainfall, relative humidity, wind and sunshine hours during the period of the experiment were collected from the IAR Metrological Station, Samaru and presented in Appendix I.

3.3 Soil Sampling

Soil samples were collected randomly from the experimental field prior to land preparation and the Departmental orchard farm from two depths of (0-15cm and 15-30cm) using a soil augar. This was done prior to fertilizer application and it was analyzed for physico-chemical properties according to standard procedures(IITA, 1991).

3.4 Treatments and Experimental Design

The treatments consisted of two soybean varieties (TGX 1835-10E and TGX1951-3Ftwo sowing methods (drilling and dibbling) and four P fertilizer rates of (0, 11, 22 and 33 kg P/ha). The treatmentsarefactorially combined and laid out in RCBD and replicated three times.The gross plot size used was $18m^2$ (4.5m width by 4m length). The Gross and net plot used was $18m^2$ (4.5m x 4m) and $3m^2$ (2m x1.5m) respectively. The pot trial was carried out in a plastic pot sized $0.039m^2$ (0.195m x

0.2m) laid out in a Complete Randomized Design (CRD) and repeated three times in the Departmental orchard farm.

3.4.1 Varietal characteristics

The two varieties of soybeans viz: TGx1835-10E and TGx1951-3F used for this research work were obtained from the International Institute for Tropical Agriculture (IITA), Kano station.

- TGx1835-10E is an early maturing variety with a maturing period of 90 days. It nodulates with diverse indigenous soil rhizobia, it smothers weeds due its broadened leaves. It's resistant to pustule bacteria, low shattering, high yieldaveraging 1.6t/ha grain and 2.2t/ha fodder, high oil content and excellent grain color.(IITA 2011).
- TGX1951-3F is an early maturing variety with a maturing period of 100 days. It performs well under erratic rainfall and has good resistance to water lodging, rust, bacterial blast and *Cercospora*leaf spot with potential grain yield of 1.5t/ha and fodder yield 2.7t/ha(IITA2011).

3.5 Cultural Practices

3.5.1 Land preparation

The experimental site was ploughed, harrowed twice to a fine tilth and ridges made at 75cm, thereafter the land was demarcatedand marked out using pegs.

3.5.2 Sowing

Sowing was done on the 25th July during the 2012 rainy season. The seeds weresown on the crest of the ridge by drilling this was done by opening the crest of the ridge in a continuous pattern and the seeds drop in the same way and covered up in two and five seeds per stand respectively. The recommended spacing of 75cm intra-row was

maintained(IITA, 1994). Dibbling was done using a 10cm cut stick to maintain the spacing between plants (2 plants per stand). The plants were sown at a depth of 5cm.

3.5.3 Fertilizer application

All plots received a basal application of 20kg N ha^{-1} using urea (46%).Pwas also applied as per treatment(0, 11, 22 and 33kg of Pha^{-1}) in both trials using single superphosphate (18%).

3.5.4 Weed control

Glyphosate(N-(Phosphonomethyl)glycine) 360EC was applied at 4L/ha a fortnight prior to land preparation. Butachlor 50EC at 4L/ha as Pre-emergence herbicides was applied a day after sowing. Subsequently, manual weeding at 3 and 6 weeks after sowing was carried out.

3.5.5 Pest and disease control

No incidence of pest and diseases infestationwas noticed throughout the trial period. The crops maintained healthy appearance.

3.5.6 Harvesting

Harvesting was done at physiological maturity, when 90% of the pods were noticed to have turned brown.

3.6Data Collection

Five plants from each plot were chosen randomly and tagged for a periodic observation that started from 4 weeks to harvest. Similarly three of the five plants were tagged in the pot trial. The data collected from the tagged plants were averaged and recorded for all the observations. The following growth parameters were assessed along with the yield parameters that were taken at harvest.

3.6.1 Stand count after emergence

Stand count was taken by counting the number of established plants at 4 weeks after sowing and at harvest. This was done in both field and pot trials.

3.6.2 Plant height (cm)

The height of the three-tagged plants was taken from ground level to the top of the growing point and the mean worked out for each plot at 4WAS, this procedure was repeated at 8 and 12WAS. This was done for both trials.

3.6.3 Number of leaves per plant

The number of fully open leavesof tagged plants in both field and pot trialswerecounted from each plot and the average recorded on per plot basis. This procedure was carried out at 4, 8 and 12WAS.

3.6.4 Number of branches per plant

The number of branches per plant of the fieldand pot-sampled plants were counted and the mean recorded at 4, 8 and 12WAS.

3.6.5 Canopy spread (cm)

The diameter of the open canopy lengthwise and breadthwise was taking using a meter ruler to measure the canopy spread at 4WAS, the procedure was repeated at 8 and 12WAS. The mean value was recorded per plot and pot.

3.6.6Number of nodules per plant

Number of nodules was taken from the tagged plants and averaged. This was done through physical observation of both field and pot tagged plants.

3.6.7 Total dry matter per plant (g)

Total dry matter of the plant was determined at 4, 8 and 12 WAS and at harvest. 3 plants per plot where carefully lifted using a narrow-bladed hoe to recover most of the roots, the samples were washed, bagged and oven-dried to constant weight, weighed using a top-loading Mettler balance and the average was taken and recorded to obtain dry matter per plant.

3.6.8Crop growth rate (CGR)

This is the measure of the increase in plant growth as described by Watson (1952).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} g/m^2/wk$$

Where W_1 = Dry weight at a sampling period

W_2 = Dry weight at the next sampling period

t_1= Time at which W_1 was taken

t_2 = Time at which W_2 was taken

3.6.9 Relative growth rate (RGR)

This is the measure of the increase in plant material per unit of initial material per unit of time (Watson,1952). The plant relative growth rate was computed using the following equation described by Watson (1947).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} g\ g^{-1}wk^{-1}$$

Where $\log_e W_1$ = Dry weight at a sampling period

$\log_e W_2$ = Dry weight at the next sampling period

t_1= Time at which$W_1$was taken

t_2 = Time at which W_2 was taken

3.6.10 Days to 50% flowering

Days to 50% flowering was determined by the count of days from sowing to the time when 50% of the plants in each plot and pot produced flowers.

3.6.11 Number of pods per plant

Pods were detached from the five-tagged samples from the plots, counted and the average taken as the number of pods per plant.

3.6.12 Pods weight per plant (g)

After harvesting, the pods from the tagged plants from the plots were detached, counted, dried, weighed and their mean recorded.

3.6.13 Grain yield (Kg ha $^{-1}$)

Grain yield per hectare was computed using the weight obtained from the net plot and pot, then converted to per hectare basis.

3.6.14 100-seed weight (g)

100-Seeds were picked randomly from each plot at harvest, weighed using a mettler balance model 1210 and the weight recorded.

3.6.15 Shelling percentage (%)

The ratio of grain yield to pod yield in both the field and pot trials was calculated using the following equation:

$$\text{Shelling percentage} = \frac{\text{Grain yield}}{\text{Pod yield}} \times 100$$

3.6.16 Harvest index (%)

This is the ratio of seed yield to the total dry matter at harvest. The harvest index (HI) was calculated using:

$$\text{Harvest index} = \frac{\text{Weight of seeds from Ykg of TDM}}{\text{Weight of Total Dry Matter}} \times 100$$

Where Y= Yield in Kg

TDM= Total Dry Matter

3.7 Data Analysis.

The data obtained wereanalyzed, using F test of significance as described by Snedecor and Cochran (1967). The treatment means were compared using Duncan's Multiple Range Test (Duncan, 1955). Correlation analysis was worked out using Statistical Analysis Software (SAS) in order to determine the relationship between growth characters, yield components and grain yield. Regression analysis was done to determine the optimum P level for maximum soybean grain yield (Steel and Torrie, 1994).

CHAPTER FOUR

4.0 RESULTS

4.1 Soil physical and chemical properties

Soil physical and chemical properties of the experimental site at 0 - 30cm depth in 2012 rainy season for the fields and pot experiment is presented in Tables 4.1. The results showed that the soil textural class of field is clay loam and sandy clay loam for the pot. Chemical composition indicated that the soils in both field and pot trials were slightly acidic (4.5 - 5.54), low in organic carbon (0.1 – 0.3) and high in total nitrogen (1.17 – 1.64). Available P (6.83 – 9.8) was moderate. Exchangeable bases in the field soil (4.0, 3.26, 0.33, 0.5, 8.2 meq/100g) were higher than those in soil used for the pot, with Ca (2.8), Mg (1.85) and CEC (7.5) appeared moderate while K (0.35) and Na (0.3)are low.

4.2 Stand count (plants per plot^{-1} and pot^{-1})

Table 4.2 shows effect of sowingmethod and phosphorus on stand count of soybean varieties during 2012 rainy season in both field and pot trials. The varieties did not differ significantly in number of stands at 3WAS and harvest in both the field and pot trials.

Drilling method of sowing gave more stands than dibbling throughout the sampling periods in both trials while application of P did not affect the stand count at all periods in the two trials. There was no significant interaction between the factors in the two trials.

Table 4.1Physical and chemical properties of soil of the experimental site at 0 - 30cm depths for 2012, rainy season.

Parameters	Field	Pot
Physical condition (%)		
Sand	32	49
Silt	36	27
Clay	32	24
Textural class	Clay loam	Sandy clay loam
Chemical composition		
PH in H_2O (1:2:5)	5.54	6.4
PH In $CaCl_2$ (1:2:5)	5.29	4.5
Organic carbon (g kg^{-1})	1.0	3.0
Total nitrogen (g kg^{-1})	11.7	16.4
Available Phosphorus mg kg-^{1}	6.83	9.8
Exchangeable bases (cmol kg^{-1})		
Ca	4.0	2.80
Mg	3.26	1.85
K	0.33	0.35
Na	0.5	0.3
CEC	8.2	7.5

Source: I.A.R, Research farm, field 212/ Agronomy Dept. Orchard, Samaru, A.B.U, Zaria

Table 4.2**:** Effects of sowing method and phosphorus rateson stand count of soybean varieties in Samaru, 2012 rainy season.

Stand	**Count**

Treatment	Field Trial/Plot 3WAS	Harvest	Pot Trial/Pot 3WAS	Harvest
Variety (V)				
TGx1951-3F	233	222	5	5
TGx1835-10E	233	231	5	5
S.E ±	0.962	0.768	0.135	0.114
Sowing method (PP)				
Dibbling	230b	222b	3b	3b
Drilling	233a	231a	5a	5a
S.E ±	0.962	0.768	0.135	0.114
Phosphorus (P kg/ha)				
0	232	233	5	5
11	233	233	5	5
22	233	233	5	5
33	233	233	5	5
S.E ±	1.360	1.086	0.191	0.161
Interaction				
V x PP	NS	NS	NS	NS
V x P	NS	NS	NS	NS
PP x P	NS	NS	NS	NS
V x PP x P	NS	NS	NS	NS

e letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

4.3 Plant Height (cm)

Table 4.3 shows response of sowing pattern and P on plant height of soybean varieties at Samaru in the 2012 rainy season. The result shows that variety TGx1951-3F significantly produced taller plants at all sampling periods, in both trials except at 4 and 12WAS in the pot trials where there was no significant response.

Sowing pattern had no significant performance on plant height at all sampling periods in both trials except at 12WAS in the pot trial, where drilling produced taller plants than dibbling method.

P application was significant throughout the sampling periods in both trials. Increase in P application from 0 to 22 kg P ha^{-1} significantly increased the plant height at 4WAS in the field further; increase to 33kg P ha^{-1} did not affect the plant height. At 8 and 12WASin field, every increase in P level resulted in a corresponding increase in plant height while at 4 and 8WAS in the pot increase in P level from 0 to 11kg P ha^{-1}increased plant height, further increase had no significant response. However at 12WAS successive increase in P application up to 22kg P ha^{-1}produced taller plants but at par with 33kg P ha^{-1}. There was significant interaction between variety and sowing method on the plant height at 8WAS in the field trial.

The interaction between variety and sowing method on plant height is shown in Table 4.4. The varieties (TGx1951-3F and TGx1835-10E) produced similar plant heights with dibbling, while drilling method produced tallest plants in both varieties. When the varieties are examined at a fixed pattern drilling recorded taller plant with TGx1951-3F than dibbling. The trend was reversed when TGx1835-10E was used.

Table 4.3: Effects of sowing method and phosphorus rates on plant height of soybean varieties in Samaru, 2012 rainy season.

	Plant Height (cm)					
	Field Trial			Pot Trial		
Treatment	**4WAS**	**8WAS**	**12WAS**	**4WAS**	**8WAS**	**12WAS**
Variety (V)						
TGx1951-3F	17.69a	45.96a	50.31a	14.90	26.23a	43.21
TGx1835-10E	15.44b	44.20b	46.47b	14.74	25.24b	43.67
S.E ±	0.345	1.667	1.722	0.202	0.330	0.310
Sowing method (PP)						
Dibbling	16.16	47.90	51.47	14.73	26.02	42.87b
Drilling	16.97	52.28	54.31	14.91	25.45	44.01a
S.E ±	0.345	1.667	1.722	0.202	0.330	0.310
Phosphorus (P kg/ha)						
0	13.83c	34.61d	34.97d	13.99b	24.51b	41.06c
11	16.10b	45.96c	47.62c	14.82a	25.93a	43.20b
22	17.92a	53.26b	56.96b	15.10a	26.35a	44.30ab
33	18.41a	66.52a	72.01a	15.38a	26.15a	45.19a
S.E ±	0.488	2.357	2.436	0.202	0.330	0.340
Interaction						
V x PP	NS	*	NS	NS	NS	NS
V x P	NS	NS	NS	NS	NS	NS
PP x P	NS	NS	NS	NS	NS	NS
V x PP x P	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. * = Significant, NS = Not Significant.

Table 4.4: Effect of soybean variety and sowing method interaction at 8WAS onplant height of during the 2012 rainy season.

	Field Trial	
	8WAS (cm)	
	TGx1951-10E	TGx1835-3F
Dibbling	50.96b	44.83b
Drilling	60.99a	43.57c
S.E±	2.357	

Means followed by the same letter within treatment group are not significantly different at 0.05 level of probability using DMRT.

4.5 Number of Leaves

Table 4.5 shows the effect of sowing method and phosphorus on number of leaves per plant of soybean varieties in Samaru during the 2012 rainy season.The result shows that there was no significant difference in number of leaves per plant between the varieties at all sampling periods in both pot and field trial except at 8WAS in the pot trial where TGx1951-3F produced a significantly higher number of leaves than TGx1835-10E.

Using both dibbling and drilling sowing method no significant difference was observed throughout the trial in both field and pot trials except at 8 and 12WAS where dibbling method produced a significantly higher numbers of leaves in the field trial only.

A corresponding increase at each increased level of P at 8 and 12WAS sampling periods in the field trial was observed, with increase from 0 to 11kg P ha^{-1}giving similar number of leaves. Application of 33kg P ha^{-1} gave the highest number of leaves per plant. However in the pot trial increasing the level of P from 0 to 22kg P ha^{-1} gave a similar number of leaves per plant at 4WAS that is lower than the number of leaves produced by application of 33kg P ha^{-1}. At 8WAS and 12WAS increasing level of P from 0 to 11kg P ha^{-1} gave a higher number of leaves per plant while further increase in P level from 11-33kg P ha^{-1} gave number of leaves per plant that were at par in the pot trial throughout the sampling periods.

There was no significant interaction between sowing method and P on number of leaves per plant in both trials.

Table 4.5: Effects of sowing method and Prates on number of leaves of soybean varieties in Samaru, 2012 rainy season

	Number of Leaves					
	Field Trial			Pot Trial		
Treatment	**4WAS**	**8WAS**	**12WAS**	**4WAS**	**8WAS**	**12WAS**
Variety (V)						
TGx1951-3F	15	43	65	15	25a	44
TGx1835-10E	14	48	78	14	34b	43
S.E ±	0.24	2.02	1.64	0.09	0.15	0.38
Sowing method (PP)						
Dibbling	14	44a	71a	14	24	43
Drilling	14	47b	62b	14	29	53
S.E ±	0.24	2.02	1.64	0.09	0.15	0.38
Phosphorus (P kg/ha)						
0	12c	35d	38d	14b	21b	22b
11	13c	36c	41c	14b	20ab	24a
22	14b	46b	54b	14b	19a	24a
33	16a	47a	64a	14a	19a	24a
S.E ±	0.34	2.86	2.33	0.13	0.21	0.54
Interaction						
V x PP	NS	NS	NS	NS	NS	NS
V x P	NS	NS	NS	NS	NS	NS
PP x P	NS	NS	NS	NS	NS	NS
V x PP x P	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

4.6 Number of Branches

The effect of sowing method and P rates during the 2012 rainy season in Samaru is shown on Table 4.6.The result shows that there was no significant difference in number of branches per plant between the varieties at all sampling periods in the pot trial and at 8WAS in the field trial. Variety TGx1835-10Eproduced higher number of branches per plant than variety TGx1951-3F at 4 and 12WAS in the field trial. Dibbling sowing method resulted in significantly higher number of branches per plant at all sampling periods in the field trial. Sowing method had no significant performance on number of branches per plant throughout the sampling periods in pot trial except at 4WAS where drilling gave a significantly higher number of branches than dibbling. A corresponding increase was observed at each increased level of P at 4 and 12WAS where 33kg P ha^{-1} gave highest number of branches per plant. However at 8WAS increased level of P from 0 to 11kg P ha^{-1} gave a significantly increased number of branches per plant while further increase from 11-33kg P ha^{-1} gave a similar number of branches per plant. Increasing level of P from 0 to 11kg P ha^{-1} gave a higher number of branches per plant in the pot trial throughout the sampling periods.Further increase in P level from 11-33kg P ha^{-1} gave number of branches per plant that were at par. There was a highly significant interaction between variety and sowing method at 4 and 8WAS in the field trial.

Interaction between variety and sowing method as shown in Table 4.7 was significant at 4 and 8WAS in field. Analysis of the result revealed that at the same pattern, varieties do not have any significant performance on the number of branches at both sampling periods using drilling methods. However when dibbling method is used variety TGx1835-10E gave higher number of branches than variety TGx1951-

3F at all periods. Sowing method had no effect on the number of branches per plant in variety TGx1835-10E at both sampling periods. However drilling gave higher number of branches per plant than dibbling using variety TGx1951-3F at both 4 and 8WAS (Table 4.6).

4.8 Canopy Spread (cm)

The response of sowing method and varying phosphorus rates on canopy spread of soybeans varieties in field and pot trials during the 2012 rainy season at Samaru are shown in table 8. The result shows Variety had no significant effect on canopy spread at 4 and 8WAS in field trial and at 8WAS in the pot trial. Variety TGx1951-3F gave wider canopy spread than Variety TGx1835-10E at 12WAS in field trial, however at 4 and 12WAS in the pot trial Variety TGx1835-10E gave wider canopy spread than Variety TGx1951-3F. Sowing method had no significant performance to canopy spread throughout the sampling period in field trial and 4WAS in pot trial. Drilling gave wider canopy spread than dibbling at 8 and 12WAS in pot trial. Varying P fertilizer rates from 0 to 11kg P ha^{-1} gave a higher canopy spread at all sampling periods in the field trial. A further increase from 11-22kg P ha^{-1} gave canopy spread that is similar. However further increase in P fertilizer level from 22-33kg P ha^{-1} gave the widest canopy spread. In the pot trial a non-significant difference was observed at 4WAS when P fertilizer rates were varied. While at 8 and 12WAS varying fertilizer rates from 0-11kg P ha^{-1} and 11-22kg P ha^{-1} significantly influenced canopy spread. Further increase to 33kg P ha^{-1} gave a canopy spread that was at par with 22kg P ha^{-1}.

There was a significant treatment interaction between variety and sowing method at 8WAS in field trial and between Variety and Prates at 8WAS in pot trial.

The interaction between variety and sowing method at 8WAS is shown in Table 4.9. The result shows that variety TGx1951-3F gave wider canopy spread than variety TGx1835-10E using dibbling sowing method while there was no significant difference between the varieties when dibbling was used. No significant influence on variety TGX1951-3Fwas observed with respect to sowing method.

The interaction between variety and Pfertilizer at 8WAS is shown in Table 4.10. The result shows that increasing P level from 0 to 22kg P ha^{-1} had no significant effect on varieties but further increase from 22 to 33kg P ha^{-1} gave wider canopy spread using variety. Increasing Prates from 0 to 22kg P ha^{-1} when variety is constant shows corresponding increase in canopy spread. Further increase from 22 to 33kg P ha^{-1} gave a similar canopy spread in both varieties.

4.11 Number of Nodules per plant

Table 4.11 shows the response of sowing method and P on nodulation per plant of soybean varieties in Samaru, 2012 rainy season.The result shows that variety and sowing method had no significant performance on number of nodules per plant throughout the sampling period in both the trials. At 4WAS, varying P fertilizer rates from 0 gave statistically lower number of nodules per plant than other treatments, which was statistically at par. At 8 and 12WAS the number of nodules produced at 33kg P ha^{-1} was statistically higher than at 0. Neither increases in Prates from 0 to 22kg P ha^{-1}or 11kg P ha^{-1} to 33kg P ha^{-1}have any significant effect on number of nodules. None of the interactions was significant.

Table 4.6: Effect of sowing method and phosphorus rates on number of branches of soybean varieties during the 2012 rainy season and pot trial in Samaru.

	Number of Branches					
Field TrialPot Trial						
Treatment	**4WAS**	**8WAS**	**12WAS**	**4WAS**	**8WAS**	**12WAS**
Variety(V)						
TGx1951-3F	9.b	19	21b	5	9	11
TGx1835-10E	10.a	20	23a	5	8	11
S.E ±	0.331	0.971	0.756	0.115	0.246	0.194
Sowing method(PP)						
Dibbling	10a	21a	24a	4b	9	11
Drilling	9b	17b	20b	5a	9	11
S.E ±	0.331	0.971	0.756	0.115	0.246	0.194
Phosphorus (P kg/ha)						
0	7d	13d	16d	5b	7b	9b
11	9c	17c	19c	6a	9a	12a
22	10b	21b	24b	6a	9a	12a
33	12a	22a	28a	6a	9a	12a
S.E ±	0.469	1.374	1.070	0.163	0.348	0.274
Interaction						
V xPP	**	**	NS	NS	NS	NS
V xP	NS	NS	NS	NS	NS	NS
PP xP	NS	NS	NS	NS	NS	NS
V x PP xP	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. ** = Highly Significant, NS = Not Significant

Table 4.7: Effects of variety and sowing methodat 4 and 8WAS on number of branches of soybean varieties during the 2012 rainy season in Samaru.

	4WAS		**8WAS**	
	TGx1951-3F	TGx1835-10E	TGx1951-3F	TGx1835-10E
Dibbling	10.73a	7.86b	25.56a	17.02b
Drilling	10.24a	10.56a	24.00a	23.21a
S.E±	0.469		1.070	

Means followed by the same letter within treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 4.8:Effectsof sowing method and phosphorus rates on canopy spread of soybean varieties in Samaru, 2012 rainy season.

	Canopy Spread (cm)					
Field TrialPot Trial						
Treatment	**4WAS**	**8WAS**	**12WAS**	**4WAS**	**8WAS**	**12WAS**
Variety(V)						
TGx1951-3F	23.02	33.38	55.97a	7.22b	24.20	40.78b
TGx1835-10E	22.53	31.89	49.81b	7.76a	24.53	44.11a
S.E ±	0.501	0.811	1.496	0.161	0.358	0.545
Sowing method(PP)						
Dibbling	22.07	33.78	52.06	7.35	23.73b	41.05b
Drilling	23.49	31.50	53.72	7.64	25.01a	43.85a
SE ±	0.501	0.811	1.496	0.161	0.358	0.545
Phosphorus (P kg/ha)						
0	19.37c	26.40c	39.90c	7.43	20.10c	33.23c
11	21.80b	31.37b	50.23b	7.27	24.44b	44.28b
22	23.77b	34.19b	56.20b	7.83	25.93a	45.63ab
33	26.16a	38.59a	65.23a	7.43	27.01a	46.66a
S.E ±	0.709	1.147	2.116	0.228	0.506	0.770
Interaction						
VxPP	NS	*	NS	NS	NS	NS
VxP	NS	NS	NS	NS	*	NS
PPxP	NS	NS	NS	NS	NS	NS
VxPPxP	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT.* = Significant,
NS = Not Significant.

Table 4.9: Interaction between variety and sowing method at 8WAS on the canopy spreadof soybean varieties during the 2012 rainy season in Samaru.

	8WAS (cm)	
	TGx1951-3F	TGx1835-3F
Dibbling	35.76a	31.00b
Drilling	31.80b	31.99b
S.E±	1.147	

Means followed by the same letter within treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 4.10: Interaction between variety and Phosphorusrates at 8WAS on the canopy spread of soybean varieties during the 2012 rainy season in Samaru.

	8WAS (cm)	
	TGx1951-10E	TGx1835-3F
0	21.05d	19.15d
11	24.11bc	24.79b
22	25.86b	26.00b
33	25.80b	28.21a
SE±	0.715	

Means followed by the same letter within treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 4.11: Effects of sowing method and phosphorus rates on number of nodules of soybean varieties during the 2012 rainy season in Samaru.

Treatment	Number 4WAS	of Nodules per 8WAS	Plant 12WAS
Variety(V)			
TGx1951-3F	4	27	43
TGx1835-10E	5	26	47
S.E ±	0.194	0.734	1.512
Sowing method(PP)			
Dibbling	5	26	43
Drilling	5	27	47
S.E ±	0.194	0.734	1.512
Phosphorus (P kg/ha)			
0	3b	24b	42b
11	5a	27ab	44ab
22	5a	27ab	45ab
33	5a	29a	49a
S.E ±	0.274	0.037	0.138
Interaction			
VxPP	NS	NS	NS
VxP	NS	NS	NS
PPxP	NS	NS	NS
VxPPxP	NS	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

4.12 Total Dry Matter (g)

Table 4.12 shows the response of sowing method and phosphorus on total dry matter per plant of soybean varieties in Samaru, 2012 rainy season.Variety had no significant effect on total dry matter per plant at 4 and 8WAS. Variety TGx1951-3Fgave a significantly higher total dry matter than Variety TGx1835-10E. However, at 12WAS and harvest,sowing method had no significant performance on total dry matter per plant throughout the sampling periods. At 4WAS increased P level from 0 to 11kg P ha^{-1}significantly increased the total dry matter. Further increase to 22kg P ha^{-1} had no effect. However, increasing the level of P from 22kg P $ha^{-1}$to 33kg P ha^{-1} resulted in increased total dry matter. Every increase in P resulted in a corresponding increase in total dry weight at 8WAS. There was no significant difference in total dry matter when P level was increased from 0 to 11kgP ha^{-1} and 11kg P ha^{-1} to 22kg P ha^{-1}. At 12WAS and at lowest, 0 gave the lowest total dry matter but was statistically at par with total dry matter at 11kg P $ha^{-1}$was applied. There was no difference in total dry matter when11kg P $ha^{-1}$was applied and with the application of 22kg P $ha^{-1}$was not significant. However when the P level was increased to 33kg P ha^{-1}a significant increase in total dry matter was observed. At harvest 0 gave the lowest total dry matter but was comparable to 11kg P ha^{-1}at 12WAS. Further increase from 11kg P ha^{-1} to 33kg P ha^{-1}resulted in higher total dry weight.

The interaction between variety and sowing method on total dry weight at 8WAS is shown in table 4.13. Variety TGx1835-10E gave a significantly higher total dry weight than variety TGx1951-3Fusing dibbling as sowing method, but variety TGx1951-3F gave a significantly higher total dry weight than TGx1835-10E when dibbling was used. Variety TGx1835-10Eproduced a higher total dry weight under

drilling sowing method than dibbling where the reverse was the case in variety TGx1951-3F.

4.14 Crop Growth Rate (CGR) (g/m^2/wk)

Table 4.14 shows the response of sowing method and phosphorus on crop growth rate per plant of soybean varieties in Samaru, 2012 rainy season.Variety TGx1951-3F gave a higher crop growth rate than variety TGx1835-10E at12WAS in field trial and at 8WAS in pot trial. No significant difference between the Varieties at 8WAS and 12WAS in field and pot trialsrespectively. Sowing method had no significant performance on crop growth rate at 8WAS in both trials. At all sampling periods in the field trial increasing P level from 0 to 11kg P ha^{-1} gave a similar crop growth rate, further increase from 11kg P ha^{-1} to 22kg P ha^{-1} and 22kg P ha^{-1} to 33kg P ha^{-1} significantly influenced crop growth rate. In the pot trial0 gave lower crop growth rate that was similar with 11kg P ha^{-1}. A significantly higher crop growth rate was observed when 33kg P ha^{-1} was applied which was also at par with 22kg P ha^{-1}. At 12WAS 33kg P ha^{-1} gave higher crop growth rate that was similar with 22kg P ha^{-1} and 11kg P ha^{-1} that were higher than the 0. There was a highly significant interaction between Variety and sowing method at 8WAS in the field trial.

Interaction between variety and sowing method on relative growth rate at 8WAS shown in table 4.15 there was no significant difference between the varieties under drilling sowing method while variety TGx1835-10E gave higher relative growth rate than variety TGx1951-3F in dibbling. There was no significant difference between the sowing methods on variety TGx1835-10E while variety TGx1951-3F gave a significantly higher relative growth rate under drilling.

Table 4.12: Effects of sowing method and phosphorus rates on total dry matter of soybean varieties during the 2012 rainy season in Samaru.

Treatment	Total Dry Matter (g) 4WAS	8WAS	12WAS	Harvest
Variety(V)				
TGx1951-3F	3.89	11.88	26.53a	21.79a
TGx1835-10E	3.79	11.18	19.95b	16.91b
S.E ±	0.165	0.534	1.948	1.510
Sowing method(PP)				
Dibbling	4.78	11.87a	26.79a	17.57
Drilling	3.90	11.18b	21.69b	21.13
S.E ±	0.165	0.534	1.948	1.510
Phosphorus (kg P /ha)				
0	2.58c	7.18d	12.21c	9.70c
11	3.58b	9.68c	18.04bc	15.11c
22	4.18b	12.20b	25.51b	21.82b
33	5.01a	17.04a	37.19a	30.78a
S.E ±	0.233	0.755	2.755	2.135
Interaction				
VxPP	NS	**	NS	NS
VxP	NS	NS	NS	NS
PPxP	NS	NS	NS	NS
VxPPxP	NS	NS	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. * = Significant, ** =Highly Significant NS = Not Significant.

Table 4.13: Interaction between Variety and sowing method at 8WAS on total dry matter of soybean Varieties during the 2012 rainy season in Samaru.

	8WAS (g)	
	TGx1951-3F	TGx1835-10E
Dibbling	13.48a	10.28b
Drilling	10.27b	12.08a
S.E±	0.755	

Means followed by the same letter within treatment group are not significantly different at 0.05 level of probability using DMRT.

Table 4.14: Effects of sowing method and phosphorus rates on Crop growth rate of soybean varieties during the2012 rainy season in Samaru

Crop Growth Rate ($g/m^2/wk$)		
	Field Trial	
Treatment	**8WAS**	**12WAS**
Variety (V)		
TGx1951-3F	10.90	23.56a
TGx1835-10E	10.23	17.15b
S.E ±	0.551	1.892
Sowing method (PP)		
Dibbling	10.93	18.72
Drilling	10.20	21.99
S.E ±	0.551	1.892
Phosphorus (P kg /ha)		
0	6.54c	10.41c
11	8.78c	15.62bc
22	11.15b	22.46b
33	15.79a	32.93a
S.E ±	0.779	2.676
Interaction		
V x PP	**	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. ** = Highly Significant, NS = Not Significant.

Table 4.15: Interaction between variety and sowing method at 8WAS on crop growth rate of soybean varieties during the 2012 rainy season in Samaru.

	8WAS($g/m^2/wk$)	
	TGx1951-3F	TGx1835-10E
Dibbling	62.87a	47.82b
Drilling	59.55a	57.94a
S.E±		2.330

Means followed by the same letter within treatment group are not significantly different at 0.05 level of probability using DMRT.

4.16 Relative Growth Rate (RGR) (g/g/wk)

Table 4.16 results shows that there was no significant response on variety and sowing methodat 8WAS. Variety TGx1951-3Fproduced a significantly higher relative growth rate than variety TGx1835-10E, drilling gave a higher relative growth rate than dibbling at 12WAS. Prates had no significant performance on relative growth rate at all sampling periods. None of the treatments interaction was significant.

4.17 Number of Days to 50% Flowering

Table 4.17 results show the response of sowing method and phosphorus on Days to 50% flowering of soybean varieties in Samaru, 2012 rainy season. The results show that there is no significant difference in number of days to 50% flowering of soybean variety on the field trial. However when the experiment was conducted in pot variety TGx1951-3Ftook longer days to reach 50% flowering. Sowing method affected days to 50% flowering in field experiment alone where, drilledsowing method took longer days to reach 50% flowering than dibbling. P application did not affect days to 50% flowering in both the trials. None of the interaction is significant.

4.18 Number of pods per plant

Table 4.18 shows the response of sowing method and phosphorus on pod number per plant of soybean varieties at Samaru, 2012 rainy season.The result shows that variety had no significant performance on number of pods per plant in both trials. A significantly higher number of pods per plant were observed with dibbling sowing method than drilling method of sowing in the field trial only. Every increase in P application gave a corresponding increasing number of pods per plant from 0 to 33kg P ha^{-1} in the field trial, while in the pot trial 0 gave significantly lower number

of pods than other rates that were statistically similar. There was no significant interaction between the treatments in both trials.

4.19 Pod weight per plant (g)

Table 4.19 shows the response of sowing method and phosphorus on pod weight per plant of soybean varieties at Samaru, 2012 rainy season.The result shows that variety TGx1951-3F gave a significantly higher pod weight per plant than variety TGx1835-10E in pot trial only. Dibbling sowing method gave a significantly higher pod weight per plant than drilling in the field trial, while a statistically similar result was obtained between the two sowing methods in the pot trial.

Increase in P application led to a corresponding increase in pods weight per plant from 0 to 33kg P ha^{-1} in the field trial, while in the pot trial 0 gave a significantly lower pods weight than other rates that were statistically similar. None of the treatment interactions were significant.

4.20 Grain yield (kg ha^{-1})

Table 4.20 shows the response of sowing method and phosphorus on grain yield per plant of soybean varieties in Samaru, 2012 rainy season.Variety had no significant effect on grain yield in the pot trial. In the field trial Variety TGx1951-3Fproduced a significantly higher grain yield than variety TGx1835-10E. There was no significant difference between dibbling and drilling in terms of grain yield in the field trial. Drilling gave a significantly higher grain yield than dibbling in pot trial.

Increasing P fertilizer level from 0 to 33kg P ha^{-1} gave a significantly corresponding increase in grain yield in field trial. However in the pot trial increasing P level from 0 to 11kg P ha^{-1} increased grain yield further increase beyond 11kg P ha^{-1} did not influence grain yield. None of the interactions was significant.

Table 4.16: Effects of sowing method and phosphorus rates on relative growth rate of soybean Varieties during the 2012 rainy season in Samaru.

	Relative Growth Rate (g/g/wk)	
Field Trial		
Treatment	**8WAS**	**12WAS**
Variety (V)		
TGx1951-3F	0.27	0.18a
TGx1835-10E	0.26	0.13b
S.E ±	0.016	0.016
Sowing method (PP)		
Dibbling	0.28	0.13b
Drilling	0.26	0.19a
S.E ±	0.016	0.016
Phosphorus (kg P /ha)		
0	0.26	0.13
11	0.25	0.14
22	0.26	0.18
33	0.30	0.19
S.E ±	0.023	0.023
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

Table 4.17: Response of sowing method and phosphorus rates on days to 50% flowering of soybean varieties in Samaru, 2012 rainy season.

	Days to 50% Flowering	
	Field Trial	Field Trial
Treatment		
Variety(V)		
TGx1951-3F	51.0	54.0a
TGx1835-10E	51.0	51.0b
S.E ±	0.45	0.31
Sowing method (PP)		
Dibbling	50.0b	53.0
Drilling	52.0a	53.0
S.E ±	0.45	0.31
Phosphorus (kg P /ha)		
0	51.0	53.0
11	51.0	53.0
22	52.0	53.0
33	52.0	53.0
S.E ±	0.64	0.43
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

Table 4.18: Effect of sowing method and phosphorus rates on number of pods per plant of soybean varieties in Samaru, 2012 rainy season.

Number of pods per plant		
	Field Trial	**Pot Trial**
Treatment		
Variety (V)		
TGx1951-3F	29	6
TGx1835-10E	30	7
S.E ±	1.6	0.2
Sowing method (PP)		
Dibbling	33a	6
Drilling	25b	6
S.E ±	1.6	0.2
Phosphorus (P kg /ha)		
0	17d	2b
11	45c	3a
22	49b	3a
33	57a	3a
S.E ±	2.2	0.3
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

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Table 4.19: Effect of sowing method and phosphorus rates on Pod weight per plant of soybean varieties in Samaru, 2012 rainy season.

	Pod weight per plant (g)	
	Field Trial	**Pot Trial**
Treatment		
Variety (V)		
TGx1951-3F	16.02	3.36a
TGx1835-10E	16.57	2.10b
S.E ±	0.278	0.061
Sowing method (PP)		
Dibbling	17.07a	3.00
Drilling	15.52b	3.00
S.E ±	0.278	0.067
Phosphorus (kg P ha)		
0	14.44c	2.38b
11	15.27c	3.33a
22	16.64b	3.48a
33	18.83a	3.52a
S.E ±	0.387	0.087
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

Table 4.20: Effects of sowing method and phosphorus rates on grain yield kg ha^{-1} of soybean varieties in Samaru, 2012 rainy season.

	Grain yield (kg ha^{-1})	
	Field Trial	**Pot Trial**
Treatment		
Variety (V)		
TGx1951-3F	2618.0a	1903.2
TGx1835-10E	2254.8b	1848.0
S.E ±	71.886	53.948
Sowing method (PP)		
Dibbling	2288.7	1203.7b
Drilling	2484.4	1347.5a
S.E ±	71.886	53.948
Phosphorus (P kg/ha)		
0	1709.9d	1663.2b
11	2638.1c	1785.8a
22	2832.6b	1893.5a
33	2965.5a	1909.8a
S.E ±	0.387	5.584
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

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4.21 100-Seed weight (g)

Table 4.21 shows the response of sowing method and phosphorus on 100-Seed weight per plant of soybean varieties in Samaru, 2012 rainy season.Variety and sowing method had no significant influence on 100-Seed weight in both trials. P application rates did not influence 100-Seed weight in the field trial. However in the pot trial, 11kg P ha^{-1} produced the least 100-Seed weight while the rest of the Prates, were at par with each other. None of the treatment interactions was significant in both trials.

4.22 Shelling percentage (%)

Table 4.22 shows the response of sowing method and phosphorus on shelling percentage per plant of soybean varieties in Samaru, 2012 rainy season.Neither variety nor sowing method had significant influence on shelling percentage in both trials. Increase in application of P fertilizer from 0 to 11kg P ha^{-1} andbeyond did not have any significant effect in the field trial. Phosphorus application rate had no significant effect on shelling percentage in the pot trial. None of the treatment interactions were significant.

4.23 Harvest index (%)

Table 4.23 shows the result of harvest indices to sowing method and phosphorus on soybean varieties in Samaru, 2012 rainy season.The result shows that variety TGx1835-10E gave a higher harvest index in both trials. Sowing method had no significant influence on harvest index in fieldtrials while drilling gave a higher harvest index than dibbling in the pot trial. Application of P fertilizer significantly influenced soybean harvest indicesperformance only in the field trial. Applying22 and 33kg P ha^{-1} resulted in similar and significantly higher harvest index than of the

least that was at par with the recorded values of 0 and 11kg P ha^{-1}. Varying sowing method between drilling and dibbling did not have any significant effect on harvest indices in both trials.Nosignificant interaction was observed.

4.24Correlation Studies

The relationship between grain yield, growth and yield component of soybean during both trials in field and pot at Samaru are presented in Tables 4.24 and 4.25 respectively. Positive and highly significant correlation coefficients were obtained between grain yield and plant height, number of leaves, branches pods per plant, pods weight per plant and canopy at 12WAS in the field trial. While the correlation matrix between grain and days to 50% flowering and weight were positive and non-significant, while harvest index were negatively and non-significant.

A positive and highly significant result was obtained between grain yields, plant height at 12WAS and harvest index in the field trial. In the pot trial the observations shows a significant correlation coefficients between grain yield and plant height, canopy spread and harvest index (Table 4.24).

Also observed in the pot trial were a non significant association between grain yield and number of leaves per plant, days to 50% flowering, number of pods per plant, pods weight per plant and 100-Seed weight (Table 4.25).

4.26Regression

When the soybean grain yield was regressed against the P fertilizer rates in the field trial, a linear response with coefficient of determination (R^2) value of 0.9987 was observed as the best fit for the data. This implies that grain yield increased with each increase in P fertilizer rate from 11 up to 33kg P ha^{-1} in the study without reaching an optimum rate (Figure 1). Again, when the response was examined in the pot trial,

same trend was observed. The linear response recorded an R^2 value of 0.9213, which indicated that it was the best fit (Figure 2).

Table 4.21**:** Effects of sowing method and phosphorus rates on 100-Seed weight (g) of soybean varieties in Samaru, 2012 rainy season.

	100-Seed weight (g)	
	Field Trial	**Pot Trial**
Treatment		
Variety (V)		
TGx1951-3F	18.99	12.70
TGx1835-10E	19.38	12.61
S.E ±	0.168	0.274
Sowing method (PP)		
Dibbling	19.13	12.47
Drilling	19.24	12.84
S.E ±	0.168	0.274
Phosphorus (P kg/ha)		
0	18.99	11.55b
11	19.16	12.79a
22	19.26	13.03a
33	19.33	13.23a
S.E ±	0.238	0.387
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

Table 4.22: Effects of sowing method and phosphorus rates on shelling percentage (%) of soybean varieties in Samaru, 2012 rainy season.

	Shelling Percentage (%)	
	Field Trial	Pot Trial
Treatment		
Variety (V)		
TGx1951-3F	66.4	73.2
TGx1835-10E	69.6	74.7
S.E ±	1.535	1.283
Sowing method (PP)		
Dibbling	65.9	74.4
Drilling	70.1	73.5
S.E ±	1.535	1.283
Phosphorus (P kg/ha)		
0	58.45b	74.48
11	68.04a	72.34
22	73.78a	73.99
33	71.80a	75.01
S.E ±	2.170	1.814
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant.

Table 4.23: Effects of sowing method and phosphorus rates on harvest index of soybean varieties in Samaru, 2012 rainy season.

	Harvest Index (%)	
	Field Trial	Pot Trial
Treatment		
Variety (V)		
TGx1951-3F	86.3b	72.6b
TGx1835-10E	92.2a	82.1a
S.E ±	4.7	6.2
Sowing method (PP)		
Dibbling	90.2	78.6b
Drilling	88.3	76.8a
S.E ±	4.8	6.2
Phosphorus (kg P /ha)		
0	78.1b	71.7
11	82.4a	69.6
22	89.1a	80.1
33	90.4a	78.0
S.E ±	6.1	8.8
Interaction		
V x PP	NS	NS
V x P	NS	NS
PP x P	NS	NS
V x PP x P	NS	NS

Means followed by the same letter within a column and treatment group are not significantly different at 0.05 level of probability using DMRT. NS = Not Significant

Table: 4.24

Correlation Matrix between soybean Grain Yield and other growth and yield characters during 2012 Samaru Field trial

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1.000									
2	0.803**	1.000								
3	0.590**	0.647**	1.000							
4	0.457**	0.490**	0.870**	1.000						
5	0.749**	0.705**	0.664**	0.595**	1.000					
6	0.155NS	0.157NS	0.513NS	0.015NS	0.266NS	1.000				
7	0.505**	0.561**	0.859**	0.893**	0.573**	-0.028NS	1.000			
8	0.433**	0.502**	0.652**	0.713**	0.486**	-0.025NS	0.690**	1.000		
9	0.112NS	0.060NS	-0.037NS	-0.138NS	-0.119NS	0.116NS	-0.114NS	0.007NS	1.000	
10	-0.234NS	-0.286*	-0.255NS	-0.092NS	-0.305*	-0.065NS	-0.102NS	-0.027NS	-0.139NS	1.000

1. Grain yield (kg ha^{-1})
2. Plant height (cm) per plant at 12WAS
3. No. of leaves per plant at 12WAS
4. No. of branches per plant at 12WAS
5. Canopy spread at 12WAS
6. Days to 50% flowering
7. Number of pods per plant
8. Pod weights per plant
9. 100-Seed weight
10. Harvest Index

Degree of freedom (46-2=44)

* = Significant at p = 0.05

** = Highly Significant

NS = Not Significant

Table: 4.25
Correlation Matrix between soybean Grain Yield and other growth and yield characters during 2012 Samaru Pot trial

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1.000									
2	0.381**	1.000								
3	0.048NS	0.331*	1.000							
4	0.297*	0.568**	0.533**	1.000						
5	0.396**	0.685**	0.453**	0.853**	1.000					
6	0.098NS	-0.132NS	0.187NS	0.181NS	-0.131NS	1.000				
7	0.066NS	0.129NS	-0.098NS	0.172NS	0.283NS	-0.467**	1.000			
8	0.067NS	0.491**	0.551**	0.711**	0.511**	0.300*	0.137NS	1.000		
9	0.029NS	0.202NS	-0.042NS	-0.018NS	0.199NS	-0.181NS	0.007NS	-0.193NS	1.000	
10	0.896**	0.228NS	-0.101NS	0.010NS	0.176NS	-0.084NS	0.100NS	-0.227*	0.053NS	1.000

1. Grain yield (kg ha^{-1})
2. Plant height (cm) per plant at 12WAS
3. No. of leaves per plant at 12WAS
4. No. of branches per plant at 12WAS
5. Canopy spread at 12WAS
6. Days to 50% flowering
7. Number of pods per plant
8. Pod weights per plant
9.100-Seed weight
10. Harvest Index

Degree of freedom (46-2=44)
* = Significant at p = 0.05
** = Highly Significant
NS = Not Significant

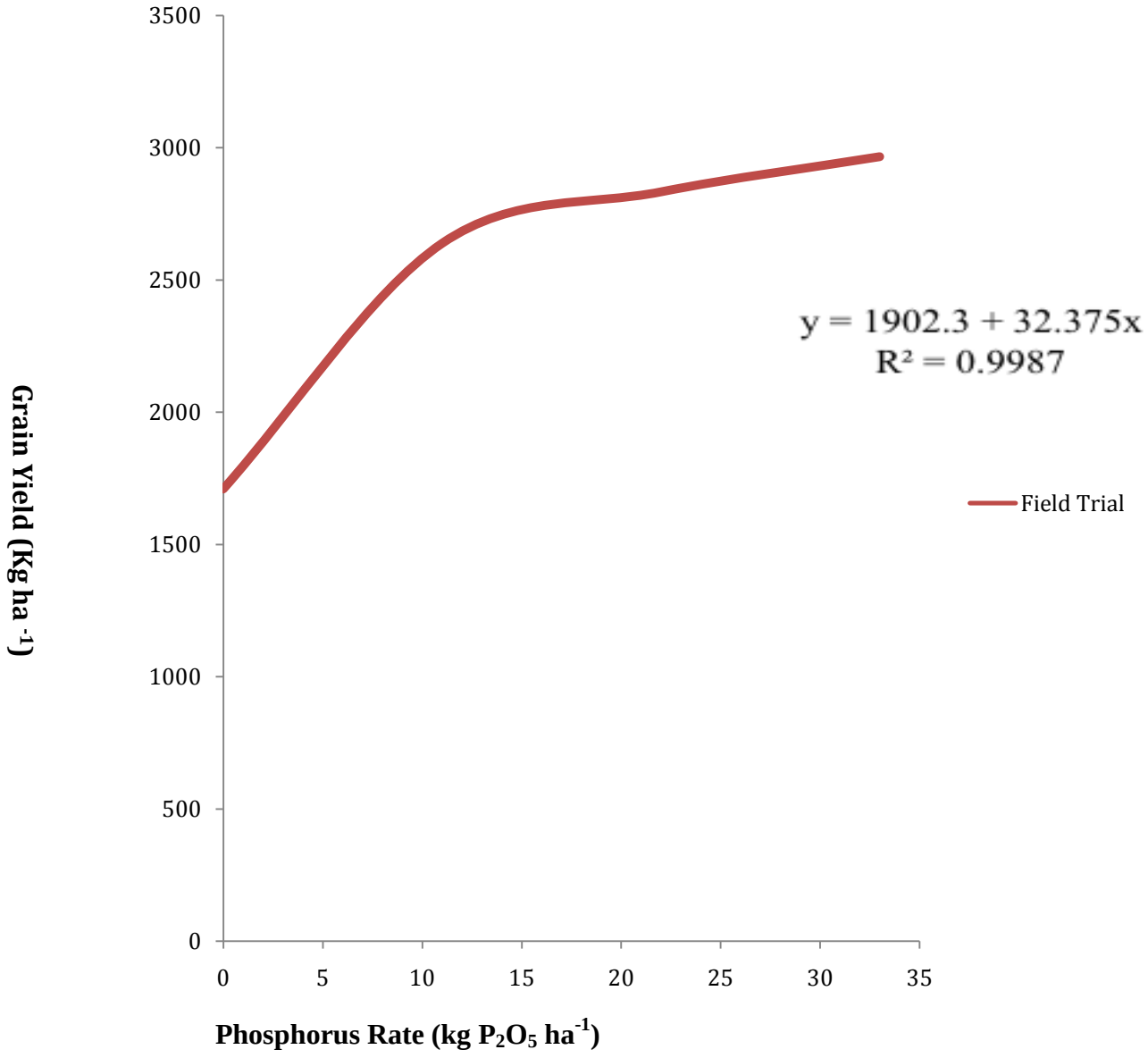


Figure 1: Regression analysis of grain yield of soybean to Phosphorus rate in field trial 2012 rainy season

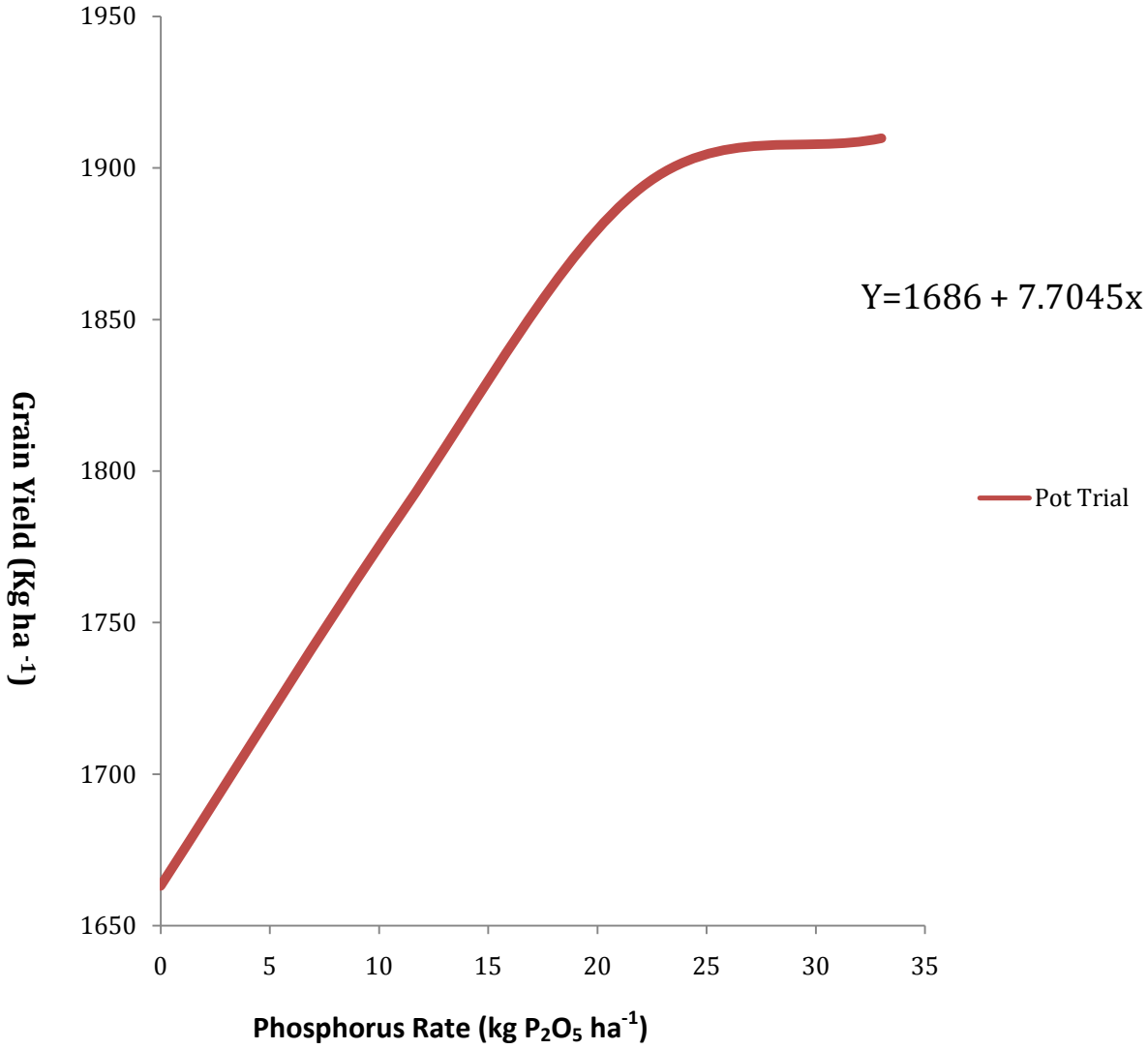


Figure 2: Regression analysis of grain yield of soybean to Phosphorus rate in pot trial 2012 rainy season

CHAPTER FIVE

DISCUSSIONS.

5.0 General Performance of Soybean.

The crop growth and yield recorded in the two trials could be attributed to the amount of rainfall received and its distribution during the two trials. The rainfall was adequate for both vegetative and reproductive stages of the crop in both trials. The good performance of the crop could probably be due to the relative higher total N (11.7 and 16.4 g kg^{-1}) content and available P (6.83 and 9.8 mg kg^{-1})in the soils of the experimental sites. This is attributed to the fact that N and P are essential nutrients necessary for the stimulation of rapid vegetative growth because of their importance in photosynthesis, formation of chlorophyll, nucleic acid, root formation and amino acid (Bonner 1952, Hanway and Weber 1971; Evans 1975; Samuel 1980 and Anon 1985). Under low fertility the plants will be unable to obtain required nutrients in adequate amounts for good growth and development thereby affecting the crop yield. Adeosun,(2000) study on rice reported similar findings, where he stressed that the low yield of rice was obtained due to low rates of soil nutrients, pH, organic matter, available P and total nitrogen which made the crops unable to maximally utilize them for carbohydrate synthesis, the consequence of which was ultimately growth and yield reduction.

5.1 Soybean varietal response.

The two varieties differed significantly in most of the growth parameters,TGx1951-3F recorded taller plants with large canopies, TDM at 12WAS and at harvest, CGR and RGR at 12WAS, longer days to 50% flowering,pod weight per plot and grain yield than TGx1835-10E. On the other hand TGx1835-10E had more number of

branches and harvest index. The variations in some of these growth parameters could be attributed to inherent genetic makeup of these varieties. Varietal response to canopy spread was significant in both trials, with 12WAS in the field trial and 4WAS and 12WAS in the pot trial. Joshi etal., (2013) reported similar findings that significant differences exist amongst soybeans genomic compositions, which are highlighted in their phenotypic variation.

The reasons for this could be that TGx1951-3F is an early maturing variety but with a longer maturing period than TGx1835-10E, so that at 4WAS it had grown better than the later variety but at subsequent periods it had started the reproductive growth and the vegetative growth had slowed down. The ability also of the variety TGx1951-3F to perform under erratic rainfall and its good water lodging resistance ability may have contributed to its performance under the low amount of rainfall received from sowing to the first few week and the high amount of rainfall recorded at 8 and 12WAS. Chuwang P.Z, (1997) reported similar findings.

5.2 Soybean response to sowing method.

Drilling produced taller soybeans plant at 12WAS with wider canopies at 8 and 12WASand stand count than dibbling. This could be attributed to increased competition for light and other growth factors (H_2O, space, light, temperature etc), as a result of higher plant population in drilled plants. This study showed that drilling significantly produced crops with wider canopy.Likewise, the higher plant population in the drilled soybean plants might have led have increased areas occupied by the roots thereby leading to increase in fixation which in turn led to crop with larger canopy. It is also expected that the area covered by leaves at high plant population will increased. Parvez, (1989) and Chiezey et al., (1992) recorded similar

findings. This could be the reason attributable to the increase in number of plants per unit area with drilling that increased the number of emerged seedlings. However, dibbling with optimum plant population led to the higher total dry matter, pods weight, number of pods, RGR, number of branches, number of leaves, recorded in this study could be attributed to the genetic makeup of the crop which allowed for the efficient utilization of growth resources (nutrients, moisture, light etc.) thereby making the crop's grow vigorous and produced high yield. Chiezey et al., (1993) and Amodu, (2004) reported similar findings.

5.3 Soybean response to phosphorus application.

Application of P enhanced vegetative growth of soybean. This is because P application caused increase in the leaf area index, number of leaves, leaf dry weight, stem dry weight, number of primary branches, number of nodules, nodule dry weight, plant height and number of days to 50% flowering. Adesoji, (1997). These increases in growth parameters confirmed the importance of P as an essential nutrient required for rapid vegetative growth of soybean because of its role in the formation of high energy molecules, synthesis of cell constituents, and in the formation and translocation of carbohydrates, fatty acids and nucleo proteins (DeMooy*et al.,* 1973).

The application of P stimulated leaf expansion; hence more light interception for photosynthetic activity and high assimilate accumulation. Number of days to 50% flowering remained unchanged with P application contrary to the earlier reports by Chiezey et al., (1992) where P application increased the vegetative phase. Nodulation increased with P application.The plants that received the least application of P fertilizer had a poor canopy development, thus the reason for their

inability to sufficiently utilize the available sunlight. This agrees with the findings of Chiezey, (1990) who reported poor canopy development of soybean plants that received no P fertilizer.

5.4 Interactions between Phosphorus and Sowing Method on Soybean Growth and Yield.

Plant height and total dry matter showed significant interactions with variety and sowing method at 8WAS. The interactions between variety and sowing method were significant at 8WAS in the field trial where drilling gave taller plants with TGx1951-3F, while TGx1835-10Egave shorter plant; however TGx1951-3Fproduced higher dry matter with dibbling method that was statistically similar to TGx1835-10E with drilling method. Variety and sowing method gave wider canopy spread in dibbling using TGx1835-10E that was at par with TGx1951-3F. Varying Prates of 33kg/ha^{-1} to 11kg/ha^{-1} gave results that were similar that were higher than 0 using TGx1835-10E, 33kg/ha^{-1} gave a wider canopy using TGx1951-3F with varying rates of 22kg/ha^{-1} to 11kg/ha^{-1} giving results that were similar to 0 in both trials at 8WAS.

5.5 Correlation studies.

A positive and highly significant correlation coefficient were obtained between grain yield and plant height, number of leaves, number of branches, canopy spread and number of pods, each per plant at 12WAS, however, there was no significant correlation between grain yield and days to 50% flowering, Harvest index and 100seed weight in the field trial. Similarly there was positive and highly significant correlation between grain yield and plant height at 12WAS, canopy spread and harvest index, moreover there was positive significant correlation between grain

yield and number of branches per plant at 12WAS.However, there was no significant correlation between grain yield and days to 50% flowering, number of pods per plant, pod weight per plant and 100-seed weight in the pot trial.The results are in agreement with Faisal *et al*., (2007) who observed significant and positive correlation of grain yield with days to maturity, plant height and number of branches per plant. Arshad *et al*., (2006) also reported significant correlation of grain yield with days to maturity, number of branches per plant and 100-seed weight. Basavaraja *et al*., (2005) determined the positive correlation of seed yield with 100-seed weight and harvest index. Liu *et al*., (2005) also reported positive association of yield with days to maturity. Bangar *et al*., (2003) observed that the seed yield was positively and significantly correlated with 100-seed weight and followed by days to maturity, number of pod per plant and 100-seed weight among themselves were also positively significant. Chamundeswari *et al*., (2003) reported positive correlation of seed yield with number of pods per plant and biological yield per plant. Significant positive correlation of yield with number of pods per plant and 100-seed weight characters has been reported by Khanghah & Sohani, (1999) in soybean.

5.6 Regression Response.

When soybean grain yield was regressed against the P fertilizer levels, it was revealed that positive linear response fitted the data best indicating that each increase in P fertilizer rate was followed by an increase in soybean grain yield in both the field and pot trials. All parameters assessed increased with increasing phosphorous rate up to 33 kg P^{-1} except crop growth rate and shorter days to flowering. Application of 33 kg P^{-1} gave55% yield increase over the control. This indicates that

soybean is responsive to P fertilization. When the yield was regressed against the rates, a linear relationship was observed. This means that the optimum rate that will give maximum economic yield has not been reached.

CHAPTER SIX

6.0 SUMMARIES AND CONCLUSION

Field and pot trials were conducted during the 2012 rainy season at the research farm of the Institute for Agricultural Research, Samaru ($11^0 11^I$, 07^0 38^0E and 686m above sea level) and in the orchard of the Department of Agronomy, Ahmadu Bello University Samaru, Zaria to test the performance of soybean varieties (TGx1951-3Fand TGx1835-10E) to sowing methods (drilling and dibbling) and varying P fertilizer rates(0, 11, 22 and 33kg P ha^{-1}). The treatments in the field were laid in randomized complete block design (RCBD)and complete randomized design (CRD) in the pot trial replicated three times in all possible factorial combinations. The data collected during the trials included growth components such as plant height, number of leaves per plant, number of branches per plant, days to 50% flowering, yield and yield components such as number pods per plant, pods weight per plant were also taken.

The result showed that variety had no significant performance on grain yield in the pot trial. Though variety TGx1951-3Fgave a significantly higher grain yield than variety TGx1835-10E in the field trial. Increasing P fertilizer level from 0 to 33kg P ha^{-1} gave a significantly corresponding increase in grain yield during field trial. In the pot trial higher grain yield was obtained at P fertilizer level 33kg P ha^{-1} which was similar to rates 22kg P ha^{-1} and 11kg P ha^{-1} and higher than 0.Variety did not affect days to 50% flowering during the 2012 rainy season experiment. However in the pot trial variety TGx1951-3Ftook longer days to reach 50% flowering. Drilling took longer days than dibbling to reach 50% flowering; no statistical difference was

recorded in the pot trial. P application did not show any significant performance on days to 50% flowering throughout the trials.

Corresponding increase at each increased level of P at 33kg P ha^{-1} gave highest number of branches per plantat 4 and 8WAS. Increased level of P from 0 to 11kg P ha^{-1} gave a significantly higher number of branches per plant while further increase from 11-33kg P ha^{-1} gave similar number of branches per plant in the field trial at 12WAS. Increasing level of P from 0 to 11kg P ha^{-1} gave ahigher number of branches per plant while further increase in P level from 11-33kg P ha^{-1} gave number of branches per plant that were at par in the pot trial throughout the sampling periods.

The regression analysis revealed that grain yield increased from 0 to 33kg P ha^{-1}whererecorded an increase in yield; this is probably due to the fact that the optimum fertilizer application level has been reached. From the results obtained it is suggested that 10cm spacing of two plants per stand produced the highest yield in the two varieties, dibbling performed better than drilling, thus dibbling sowing methods is hereby suggested.

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APPENDICES

Month	R/H %	MAX TEMP ^{O}C	MIN TEMP ^{O}C	Sunshine/hr	Rainfall/mm	Wind km/hr
April	51	39	23	7.20	7.3	186.29
May	68	34	21	5.94	263.4	178.30
June	76	32	22	6.70	120.7	176.50
July	83	30	20	5.23	165.3	160.01
August	82	29	19	4.50	426.7	135.16
September	77	30	20	5.02	270.3	93.94
October	70	34	21	7.32	79.6	95.60

Appendix 1: Meteorological weather report for 2012 rainy season,Samaru.
Source: IARMeteorological Station



Plate 1a; Sowing in the field.



Plate 1b; Established Soybean plants in the Departmental orchard.



Plate 1c; The candidate measuring canopy spread in the field.



Plate 1d; General review of the field experiment with the candidate andthe major supervisor.



Plate 1e; the candidate conducting Field observation on soybean crop pods.

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